System Impact Study Report

PV Generation Interconnection Study

Shelter Cove Resort Improvement District #1 (Shelter Cove)

Pacific Gas and Electric Company

WE DELIVER ENERGY.

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Table of Contents

1. Executive Summary

Shelter Cove Resort Improvement District #1 (Shelter Cove) submitted an interconnection request to Pacific Gas & Electric Company (PG&E) to determine feasibility of connecting residential solar (PV) generation to its system. On Oct 10, 2012 PG&E and Shelter Cove executed a System Impact Study (SIS) Agreement.

Pursuant to the SIS Agreement, PG&E performed studies to determine whether the proposed interconnection project created any adverse system impacts. Specifically, the SIS was performed to identify the following:

- System impacts caused solely by the addition of proposed Shelter Cove residential PV projects
- System reinforcements, if any, necessary to mitigate any adverse impacts caused by the proposed projects under various system conditions

To identify distribution system impacts caused by the projects, studies were performed using expected future system conditions. Studies performed for this System Impact Study (SIS) include:

- Steady State Power Flow Analysis
- Steady State Voltage Analysis
- Transitive Voltage Analysis
- System Protection Analysis

PG&E's steady state power flow analysis and steady state voltage analysis concluded the interconnection of the proposed project does not cause any adverse system impacts.

The transitive voltage analysis determined that voltage deviations would be within acceptable limits up to an aggregate of 250 kVA nameplate PV generation. Shelter Cove shall provide updates of aggregate installed PV generation to PG&E. Should Shelter Cove wish to exceed this limit, it must notify PG&E in advance so that PG&E may review the impact of such additional solar generation on PG&E's system.

The protection analysis determined the need to update present drawings, install the proposed Viper recloser or a similar breaker, install a separate under power relay, and eliminate or interlock the proposed by-pass switch. All of these protection improvements are to be documented on a Single Line Diagram (SLD) and provided to PG&E for review and approval.

2. Project and Interconnection Information

Shelter Cove is proposing to interconnect small (10 kVA nameplate or less), residential solar generation to its system for parallel operation with PG&E. Shelter Cove is served through approximately 24 circuit miles of 12 kV distribution line. There are six stages of voltage regulation on this line between Shelter Cove and PG&E's Garberville Sub.

3. Voltage Regulation

PG&E is not required to regulate the voltage on its system to meet the needs of its FERC jurisdictional customers. Shelter Cove should specify tap ratios for its system and install equipment to regulate voltage to meet its system needs and requirements.

4. Study Assumptions

PG&E conducted the SIS using the following assumptions:

1) Parallel operation of generation shall be limited to residential PV systems.

2) Individual PV systems shall not exceed 10 kVA nameplate.

3) Equipment installed must be on the current CEC list of approved devices and be certified under UL-1741.

5. Steady State Power Flow Study and Results

The steady state power flow model showed improvement in baseline equipment loading with the addition of PV generation at Shelter Cove. No adverse system impacts were identified under steady state conditions.

6. Steady State Voltage Analysis

The steady state voltage analysis showed improvement in baseline voltage levels with the addition of PV generation. No adverse system impacts were identified under steady state conditions.

7. Transitive Voltage Analysis

The transitive voltage analysis revealed a high level of sensitivity to swings in generation output. Rapid changes in generation output of as little as 125 kVA can result in unacceptable voltage deviations at the PG&E point of interconnection. With PV generation, rapid swings in output are unlikely to occur except in situations involving patchy clouds or fog banks rolling in off the coast. In order to determine the impact of such weather anomalies on the output of PV systems, data from two existing PV systems was reviewed. [The data was taken from days known to exhibit such conditions.]

It was determined from this historical data that PV systems subjected to these conditions will experience a swing of approximately 50% in generation output. This results in a practical limit for the Shelter Cove PV project of 250 kVA aggregate nameplate rating. Should Shelter Cove wish to exceed this limit, it must notify PG&E in advance so that PG&E can review the impact of such additional solar generation on PG&E's system. Given the sensitivity of this issue and consistent with the WDT Service Agreement, it is important that Shelter Cove provide PG&E with updates of aggregate installed PV generation.

This study was focused on the impact to PG&E's system, not Shelter Cove's system. PG&E feels that the voltage swing on Shelter Cove's system due to a rapid decrease in PV generation in Shelter Cove's system would be greater than that seen at the PG&E point of interconnection. We recommend that Shelter Cove perform a detailed study of its own system to determine the transient voltage impact on Shelter Cove's system.

8. System Protection Analysis

The system protection analysis determined the following items will be necessary in order to safely connect PV generation in parallel with PG&E's distribution system:

Install Under Power Relay:

A separate Under Power relay shall be installed to trip the proposed Viper Recloser. This system improvement will be documented on a Single Line Diagram (SLD) which Shelter Cove will provide to PG&E for its review. Settings for this relay shall be a minimum import of 15 kW with a time delay not to exceed 2.0 seconds.

Install Main Breaker:

The installation of the Viper Recloser or a similar breaker will need to be completed and documented on a SLD for PG&E's review and approval. This breaker is necessary to isolate PG&E from Shelter Cove's PV generation in the event of an under power situation.

Install By-Pass Switch Interlock:

The proposed by-pass switch must be interlocked with the disconnect air switch such that both switches cannot be closed at the same time. Closing the by-pass switch will nullify the effectiveness of the required under power relay. Interlocking these two switches will prevent Shelter Cove's generation from being paralleled with PG&E if the required protection has been by-passed. Shelter Cove's final design should be documented on a SLD and provided to PG&E for review and approval.

Develop DC Elementary Drawing:

Shelter Cove must design and submit a DC Elementary drawing for review and approval by PG&E. This drawing shall show the DC circuitry including relay and breaker contacts to trip and close the Viper Recloser as well as the battery and charging components.

Battery System Requirements:

The battery and charging components must meet the requirements set forth in the white paper entitled: Battery Requirements for Interconnection to PG&E System. See attached Appendix A.

Single Line Meter & Relay Diagram:

Shelter Cove must design and submit a Single Line Meter & Relay (SLMR) diagram for review and approval by PG&E. This drawing shows the PT and CT connections of the various relays and metering. The SLD previously provided by Shelter Cove includes this information for the proposed Viper Recloser. If the new Under Power Relay and by-pass interlock information is included on the SLD discussed above, a separate SLMR will not be necessary.

Relay Test Reports:

All required relays will need to be tested by a certified testing company with the results submitted to PG&E for review and approval a minimum of two weeks prior to pre-parallel inspection.

Pre-Parallel Inspection:

A pre-parallel inspection must be performed. This requires members of PG&E's Test Group to be onsite to witness and approve function testing of all required protective relays/apparatus. This will require the customer to have a certified test group, with all necessary test equipment, onsite to perform said function testing. A separate Work Performance Agreement will be necessary for this work activity. PG&E estimates that this will cost about $15,000 for all the related pre-parallel inspection activities.

APPENDIX A

BATTERY REQUIREMENTS FOR INTERCONNECTION TO PG & E SYSTEM

SECTION 1: GENERAL REQUIREMENTS

The purpose of this document is to ensure safety and reliability of Pacific Gas and Electric Company and its customers who will connect to our systems. The recommendations made here will ensure that the system operates as designed.

Because of serious reliability, safety and reduced life concerns with sealed (also called Valve Regulated Lead Acid – VRLA) batteries industry wide, PG & E has decided to completely stop the use of sealed batteries in our Substation or any switchgear installations or interconnection using these batteries.

Flooded lead acid (calcium, antimony) and Nickel-Cadmium (NICAD) are the only batteries acceptable in these installations. Switchgear compartments typically see very high temperatures, and if sealed batteries are used they will dry out in less than a few years causing safety and reliability concerns along with not having the capability to trip breakers.

SECTION 2: TEST COMPARISON

A side by side comparison of IEEE Std 450-2002 Section 5.2.3 (IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented lead acid batteries for Stationary applications – also referred as flooded batteries) and IEEE Std 1188-1996 Section 5.2.2 Subsections a, b & c. (IEEE Recommended Practice for Maintenance, Testing and Replacement of Valve-regulated batteries for Stationary application- also referred as VRLA) clearly demonstrates that VRLA requires yearly discharge testing and quarterly ohmic resistance testing compare to yearly ohmic testing along with 5 year interval discharge testing for flooded batteries. Annual discharge testing is not practical, as it is offline testing and requires clearance or parallel battery to conduct test and hence is not done in general industry wide. Experience industry wide also indicates problem with doing ohmic tests on VRLA because of the design of battery and trying to make connections to the terminals and interconnecting hardware. Even if ohmic resistance reading is not done on flooded battery, the failure modes can be detected by visible inspection including specific gravity and voltage measurements and using a flashlight to inspect the plates for sulphation, plate buckling, sediment deposit, terminal corrosion and cracked plates. In the sealed battery these tests are not possible and hence eliminating ohmic tests in VRLA is not acceptable. These batteries can even show dry out conditions between the quarterly interval which could lead to ultimately catastrophic failure. In hot environment VRLA would require temperature compensated charger as well as monitoring which is expensive and still not proven to be adequate. In the telecommunication industry there are presently trials under way for system wide replacements of VRLA with flooded or NICAD batteries. PG & E recommends the use of NICAD batteries in switchgear cubicles since they are more tolerable to high ambient temperatures than flooded lead acid batteries. Flooded lead acid batteries can also be used in switchgear.

Additional reasoning for not using VRLA in substation as pointed out by IEEE Battery working group Chairman in the recent paper published in IEEE.

“Summarizing the issue for VRLA batteries, there is a considerable risk involved in installing a single VRLA string in a substation. If parallel strings are installed, to operate reliably, they must be redundant, either by design or by a sufficient degree of conservatism in the sizing calculation. In building in redundancy, however, the main aim of reducing battery costs is compromised. Despite the early claims of maintenance-free operation, VRLA batteries require considerable surveillance and testing to maintain a high degree of reliability, IEEE 1188-1996 recommends quarterly internal ohmic measurements and annual discharge testing of VRLA. These measures are largely ignored by the telephone operating companies because of their low loads and use of parallel strings, as detailed above. In substation operation, however, these practices are doubly important because of the higher currents involved”.

SECTION 3: BATTERY DESIGN, INSTALLATION, TESTING AND MAINTENANCE REQUIREMENTS

Battery shall be vented lead acid type (flooded). Valve regulated lead acid (VRLA) batteries are not acceptable. Flooded Nickel cadmium or flooded lead acid calcium and antimony designs are acceptable. Flooded mono block design (more than one cell in a jar) is acceptable**.**

Battery shall follow IEEE standard 484-1996 for the Installation Design, IEEE standard 450-2002 for Maintenance, Testing and Replacement and IEEE standard 485-1997 for the battery sizing. Battery racks shall meet seismic zone 4 requirement in addition to the requirements outlined in IEEE standard 484-1996 section 5.3. Based on 100 watts continuous load (approximate 4 relays and meters) and 30 amperes momentary load, the size of the battery supplied shall be 80 AH (48 volts system) based on eight (8) hour discharge rate. The battery shall be capable of supplying load current, for 8 hours, continuously, at the C8 rate without any cell’s voltage going below 1.75 volts per cell. The battery voltage including IR drops of inter-cell and inter-rack connectors shall not fall below 43.5 volts while current is being supplied for 8 hours, continuously, at the C8 rate. The 48V battery set shall consist of 24 cells with an 8-hour discharge rating. If load requirements are different then sizing shall be performed based on IEEE standard 485-1997. Any specific design concerns should be referred to the respective sections in above-mentioned standards.

Once battery is installed a proof of three (3) hour discharge testing to ensure that the battery has the capacity to support the load and trip should be provided. Documentation showing maintenance per IEEE 450-2002 Section 5.2 (Monthly, Quarterly, and Yearly) should be submitted. Battery should be monitored for low voltage by separate voltage relay or through the charger and critical alarm to SCADA should be provided for low voltage condition.

SECTION 4: CHARGER REQUIREMENT

The battery charger shall be constant voltage, filtered, regulated and fully automatic. Charger rating of 12 amperes DC will be used for 80 AH battery. The required charger rating shall be sufficient to charge a completely discharged battery i.e.1.75 V dc per cell, to a fully charged state 2.15-2.25 volts per cell (lead-acid battery type) in 12 hours while supplying the expected normal substation load. When the battery is not 80 AH, charger should be sized based on above criteria.